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EMERGENCY DISTRESS SIGNALLING DEVICE

by

C. L. Paxton
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Final Report

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U. S. ARMY LAND WARFARE LABORATORY
Aberdeen Proving Ground, Maryland 21005

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This report describes the development and test of a rocket-launched transmitter/base-station receiver system designed to provide emergency communications capability between isolated patrols and their parent unit up to ranges of 100 miles. Upon receipt of the transmitted signal, the receiver console located at the parent unit base station produces visible and audible output signals which indicate that a specific patrol is in need of assistance.

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INTRODUCTION

In early 1971 a need was identified by the Commanding General, US Army, Alaska (USARAL) for an emergency signalling system to enable small isolated patrols to alert their parent unit of an emergency situation or condition from distances as remote as 50 to 100 miles. Operational limitations caused by terrain and environmental conditions of the Arctic severely limit the radio range of the AN/PRC-77 tactical radio system normally employed by the patrol unit.

The LWL approach is based upon the use of a narrow-band, tone coded, frequency modulation system. This narrow bandwidth design provides a high signal-to-noise ratio, and therefore, high receiver sensitivity. To obtain good signal-to-noise ratios at line-of-sight ranges in excess of the required 50 miles, a rocket system is used to elevate the transmitter package to a height of 7000 feet. Balloons as well as rockets were initially considered as elevation systems. The balloon concept was dropped because of the restrictions imposed by the weight of the heavy inflation system required and adverse effects caused by the weather conditions of the Arctic.

DEVELOPMENT

The Thiokol Chemical Corporation, Elkton, MD performed the basic design engineering and development testing of the Emergency Distress Signalling Device under the direction of the US Army Land Warfare Laboratory (USALWL).

The rocket portion of this emergency signalling device is an adaptation of the basic Remotely Initiated Illuminating Perimeter Rocket (RIPER) developed by the Wasatch Division of Thiokol for the USALWL. A new grain was designed, using the RIPER propellant, TP-L-3014, to achieve the burn time and altitude requirement of 7000 feet above ground level (AGL) for the present system.

An inexpensive, fiber-glass, tripod launcher with folding legs was designed for use as both the launcher and the rocket storage container to be carried by the patrols.

The rocket system contains a pulse encoded transmitter system supplied by USALWL. To expedite development and minimize additional cost, maximum use was made of the electronic equipment developed for an earlier USALWL task by the Bell & Howell Communication Company, Waltham, MA, the Discreet Signalling System. Except for a minor redesign of the on-off timing circuit, the transmitter portion of the system was adapted for the rocket application by repackaging. The base station receiver/decoder portion of the Discreet Signalling System provided the necessary receiver/decoder and display console for the Emergency Signalling System without modification.

A sub-contract was let to Catalyst Research Corporation, Baltimore, MD by Thiokol to develop a suitable power source for the transmitter system. Catalyst Research provided the engineering and development work to produce a thermal battery with adequate power capacity for the transmitter and a suitable firing mechanism that would fit within the existing rocket case and give positive battery activation upon deployment of the electronic package.

DESCRIPTION

The Emergency Distress Signalling Rocket System (Figure 1) is a ground-launched, rocket-boosted, parachute-deployed radio transmitter system which transmits a pulse encoded radio signal to a base station receiver system (Figure 2).

The Signalling Rocket System (Figure 3) is contained in a combination shipping and launch tube which includes folded tripod legs. The length of the rocket system is approximately 24 inches. The combined weight of the rocket and the launch tube is 5.5 pounds.

The rocket launch is initiated by an M60 fuse starter which ignites an M700 safety fuse delay. This then ignites a No. 2M Boran pellet which ignites a pyro-fuse contained inside the rocket motor. This method of activation produces a delay time of approximately 30 seconds between activation and launch permitting the operator sufficient time to move a safe distance from the launch area. The rocket attains an elevation of approximately 7000 feet (AGL) in approximately 20 seconds from launch. The solid propellant rocket motor provides a boost thrust of 40 pounds for roughly 1 second and a sustained average thrust of 5 pounds for 13 - 15 seconds prior to ignition of the ejection charge (same as first fire-transfer mix). The parachute, transmitter, and thermal battery are ejected from the body of the projectile by the ignition charge. Upon ejection the parachute deploys, the thermal battery activates, and the transmitter starts to radiate a signal. In a deployed state the parachute is 30 inches in diameter and with the attached 0.5 pounds electronic package its descent rate is approximately 10 feet per second.

The average transmitter power output is 1.75 watts at approximately 148 megahertz (MHz). The transmitter is frequency-modulated by two 2-second, sequential audio tones. The duty cycle of the transmitted signal is approximately 5 seconds on and 10 seconds off. The thermal battery will produce adequate power of 17 volts @ 150 milliamps for approximately 3 minutes. A metal shroud line of the parachute is used as the transmitter antenna.

The base-station decoder/display unit produces both a visual and audible output upon receipt of the transmitted signal. The base station receiver equipment has a .05 micro-volt sensitivity. The receiver antenna system is an RC/292 antenna modified for use at 148 MHz. The base station has a 60 channel decoding capability. Thirty operating channels and thirty back-up channels are used with the Emergency Distress Signalling System. At a minimum altitude of 3000 feet (AGL), the transmitting range is 50 miles.

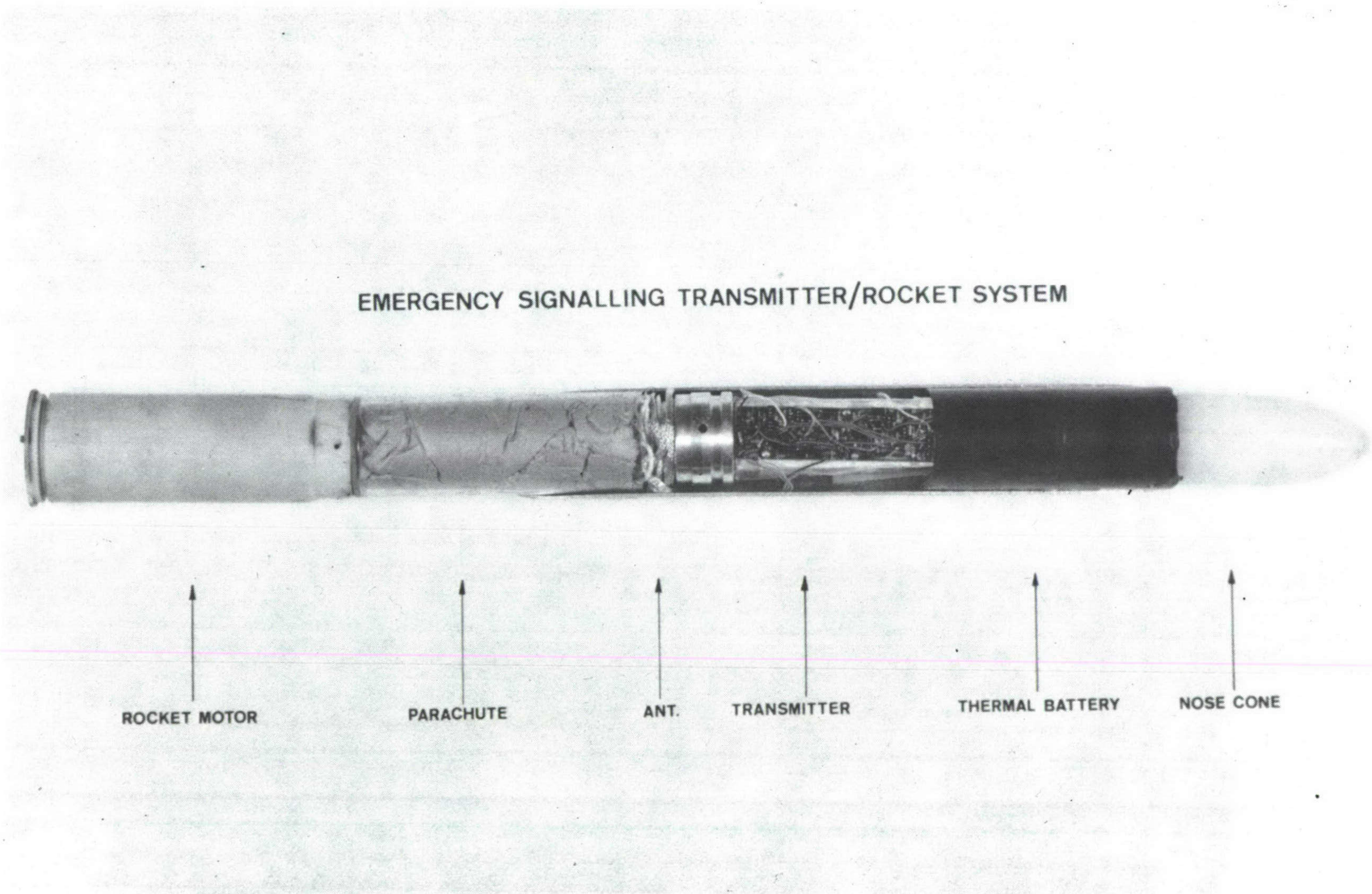

Figure 1. Emergency Signalling Transmitter/Rocket System

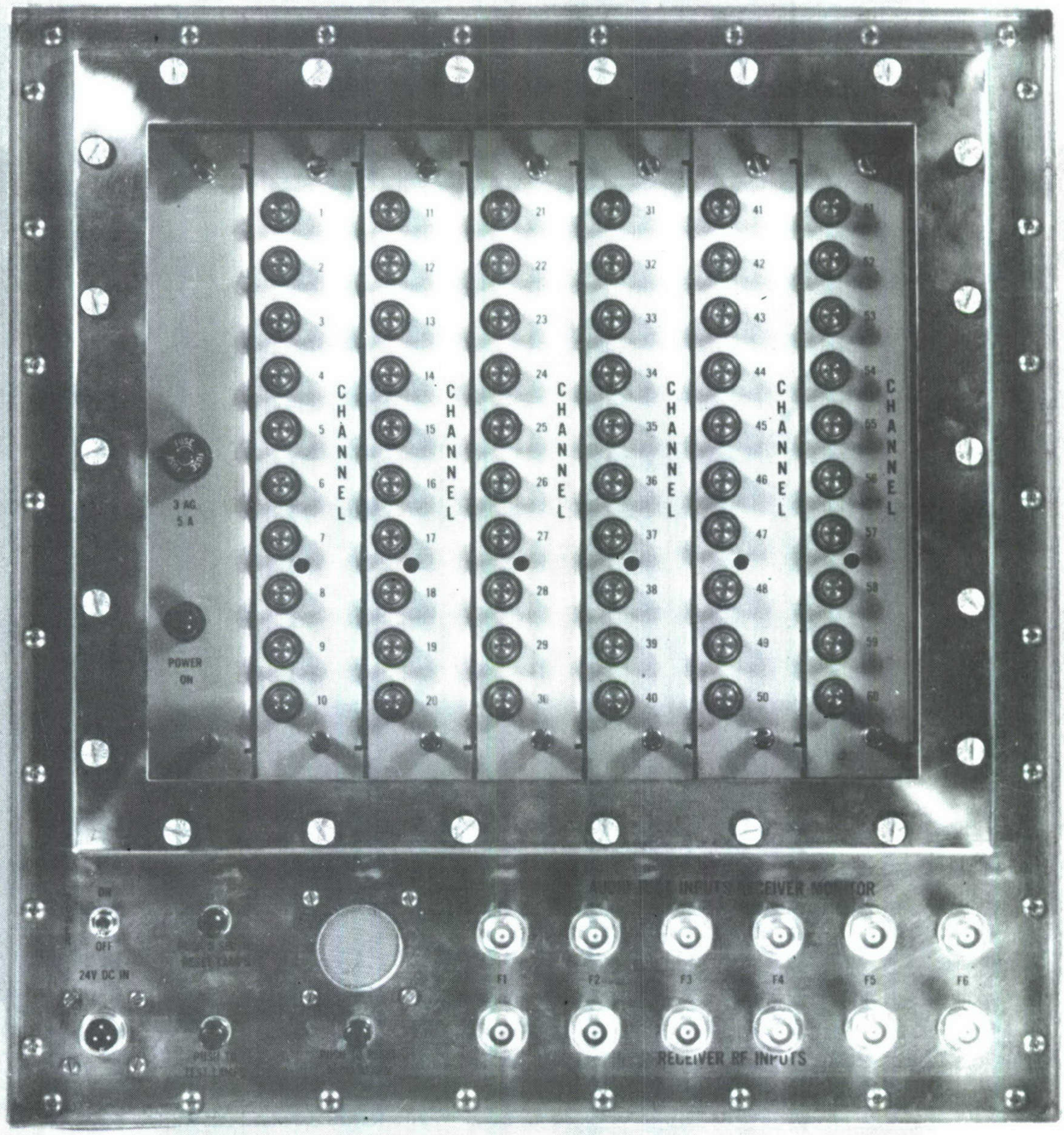

Figure 2. Base Station Console

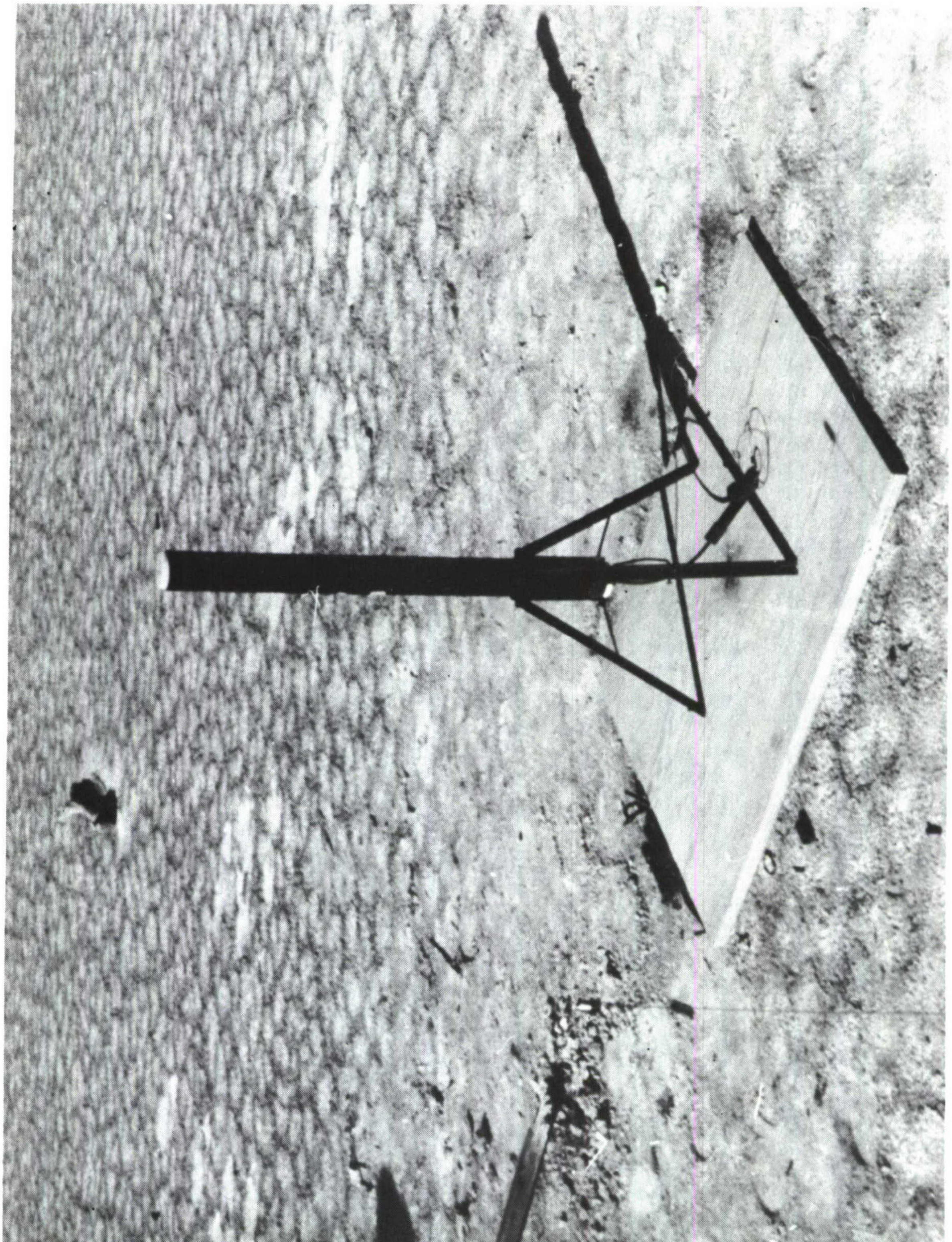

Figure 3. Emergency Signalling Rocket and Launch Tube

TESTING

The testing program was divided into three phases. The prime contractor, Thiokol Corporation, Elkton, MD performed essentially all testing under close supervision by LWL technical representatives from the Communications/ Electronics and Munition Branches of the Development Engineering Division.

Phase I of the testing program demonstrated the feasibility of using the existing RIPER System as the propulsion system for the airborne transmitter. This was successfully accomplished through actual as well as static tests conducted at the contractor's facility. This phase was concluded during late March 1972 with the flight test of three projectile systems using existing RIPER propulsion and hardware.

Phase II involved a series of rocket motor static tests conducted on a modified propulsion and expulsion/deployment system. Testing of the rocket motors started May 1972 and consisted of 18 motor firings. These tests revealed several minor problems that needed to be resolved. The principal problem was the transfer of the flame front from the propellant grain through the first fire mix to the expulsion charge. A redesigned vent for better conduction of the flame resolved the problem. A second problem surfaced during expulsion charge burn, the hot gases blew past the propellant container O-ring seal and fused the nylon parachute shroud lines together. This problem was resolved by the incorporation of a teflon seal back-up ring.

Ten complete Emergency Distress Signalling Systems were flight tested at the Wasatch Division of Thiokol, Cosmo Testing Range, located at Brigham City, Utah, as part of the Phase II test program. The purpose of these tests were to obtain dynamic test information that could not be gathered in the static test program. The program was directed by USALWL personnel and involved personnel from both the Wasatch and Elkton Divisions of Thiokol as well as the Utah Army National Guard.

The tests were conducted during August 1972 with rockets at both ambient temperature and after temperature conditioning at -65°F. The program successfully demonstrated that the Emergency Distress Signalling System would meet its operational performance goals. Table I contains a summary of the flight test results including attained altitudes based on Theodolite tracking, and also lists the number of signals detected at each receiving station. Ignition problems were encountered with four units during the Wasatch flight test program. A redesign of the ignition fire train, and a modification in pellet size corrected the problems.

Subsequent to the Wasatch flight tests, the rocket systems were subjected to vibration and drop tests conducted at the contractor's facility. The objective of these limited environmental tests was to determine the survivability or effect on the operation of the electronic package after exposure to the rigors of standard shipping and handling techniques. The transmitter package showed no apparent degradation or damage as a result of these tests.

TABLE I

EMERGENCY DISTRESS SIGNAL DEVICE FLIGHT TEST SUMMARY

Test Date: August 9-10, 1972

Location: Cosmo Test Range, Brigham City, Utah

Item	Transmitter Number	Pretest Conditioning Temperature	Attained Altitude (above Ground Level), ft.	Dual-tone FM Signals Received					Measured Descent Rate, FPS	Remarks
				HU-1 Helicopter Launch Area	Ground Station Launch Site	Sta. No. 1, Tremonton, U.	Sta. No. 2, Preston, Idaho	Sta. No. 3 TCC Airstrip Brigham City, U.		
1	15	Ambient	-	16	16	13	0	9	-	Deployment not tracked by Theodolites
2	14	Ambient	6,185	16	16	14	5	14	-	
3	19	Ambient	5,571	18	18	15	9	14	9.66	
4	20	Ambient	3,435	18	18	15	0	5	8.43	Probable case wall burn thru
5	18	Ambient	5,696	16	16	14	5	13	10.70	
6	11	-65°F	-		12	2	0	0	-	Deployment not tracked by Theodolites
7	13	-65°F	5,486		0	0	0	9	8.7	Polarity between battery & transmitter reversed
8	12	-65°F	4,880		16	15	3	14	-	Altitude based upon only 1 Theodolite reading & Wasatch's personnel's best judgment.
9	16	-65°F	None							Launch aborted, ignition failure
10	17	-65°F	5,250		15	12	8	13	-	
Distance from launch site to receiver station, mi				0	0	31.5	53.0		19.0	

Phase III of the test program dealt with flight testing conducted at both Aberdeen Proving Ground, MD and at Fort Richardson, AK. A decision was made to flight-test fifteen systems at APG and to demonstrate the remaining fifteen systems in Alaska.

The APG tests were conducted during March 1973. The launch site was located at Aberdeen Proving Ground, MD and the base-station receiving station was located approximately 60 miles away at Columbia, MD. Of the nine units launched, all projectiles functioned normally; however, only seven transmitter systems emitted a usable signal. The cause of problem with the transmitter systems could not be determined since no hardware recovery was made.

The Alaskan demonstration firings were conducted between June 4 and June 8, 1973. The launch site selected was a target impact area of Ft Richardson near the Cook Inlet. The base receiver was established at Portage, Alaska, separated from the test site by 6,900 ft high peaks. The base site was changed after some signals failed to reach this base station. A second base station site was selected at Fish Lake which provided a 50-mile distance from the launch site at Eagle River Flats separated by 4,500 ft peaks.

The test series then concluded successfully except for two unusual launches where two units failed to achieve the design altitude. The rockets left the launcher normally but at approximately 1,500 ft altitude veered off the vertical launch angle to one nearly horizontal. Observers at the launch site could see the plastic end closure fall off the ogive. The ogive had apparently carried the closure out of the launcher and the resulting drag deflected the units from a normal flight profile.

All 15 units ignited successfully and, with the exception of the two units discussed above, all worked satisfactorily with various results attained in the communication function.

Table II provides the results of the entire flight test program conducted under Phase III of the test programs.

Subsequent to these tests, USARAL expressed a desire to increase performance to provide altitudes of 12,000 ft and signalling ranges of 100 miles.

TABLE II

EMERGENCY DISTRESS SIGNAL DEVISE TEST RESULTS, PHASE III PROGRAM

Test Group	Unit S/N's Tested	Test Location/Date	Qty Tested	Projectile Operation	Transmitter Operation	General Remarks
#1	32 33 34 40 41 42 49 57 58 59	Aberdeen Proving Grounds March 23, 1973	10	9 good 1 Abort	7 good 2 "no-signal"	1) Aborted unit S/N 33 could not be launched due to mechanical failure of the fuze. Fuze pulled out of ignition train due to damage in assembly. 2) See Note 1.
#2	33 36 37 43 45 55	Aberdeen Proving Grounds April, 1973	5	1 good 1 abort		1) Aborted unit S/N 36 was an ignition failure due to termination of flame front in the GFE supplied M700 fuze. 2) Repaired Unit S/N 33 was successfully launched. 3) Clear sky conditions permitted visual sighting of deployment which was judged to be as designed. 4) See Note 1.

TABLE II (Con't)

Test Group	Unit S/N's Tested	Test Location/Date	Qty Tested	Projectile Operation	Transmitter Operation	General Remarks
#3	31, 35, 38, 39, 44, 46, 47, 48, 50, 51, 52, 53, 54, 56, 60	Ft. Richardson, Alaska June 4-8, 1973	15	13 good 2 bad	14 sets of signals received at launch point and the 10-mile distant receiver. 6 sets of signals received at a 50-mile distant base station. One unit failed to emit any signals.	1) Two units had an unsuccessful launch trajectory due to the projectile ogive capturing the plastic spacer in the launch tube. 2) Failure to receive some of the signals at the 50-mile base station may have been caused by site selection for the receiving station. 3) See Note 1.

NOTE 1: "No signal transmission" is probably attributable to a problem in the transmitter package although no instrument packages could be recovered to verify the assumption.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. The operational concept of the Emergency Distress Signalling System was successfully demonstrated to USARAL.

2. The operational performance goals of the rocket as well as the transmitter system were met. At an altitude of 7000 ft (AGL) the radio range obtained was 50 miles.

3. USARAL plans to draft a ROC to include the new altitude requirement of 12,000 ft (AGL) and the extension of the communication range to 100 miles.

Recommendations

Further design and development effort by the parent agency, ECOM, should incorporate the following recommendations:

1. The base station should be designed to withstand operational environmental conditions.

2. The physical size of the base station should be reduced, not to exceed that of an SB22 system. In support of this goal, the channel capacity can be reduced from 60 to 10 without loss of tactical versatility in this application.

3. The rocket propulsion system should be redesigned to increase altitude capability from present 7000 ft to 12,000 ft (AGL).

4. If necessary, transmitter performance should be increased to provide a 100 mile radio range.

5. Develop a frequency translator system for the AN/PRC-77 to provide launch site monitoring capability. This will provide patrols with a means for confirming transmission of distress signals.

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